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Dijfículties in visual cloud cover assessment - a study based on long-term nephologic observation series in Cracow

Trudności w wizualnej ocenie zachmurzenia - na podstawie wieloletnich obserwacji nefologicznych w Krakowie

A look at the sky may be the first act of daily conscious contact with the atmosphere for most of us, but an assessment of the cloud cover stili tums to be a difficult task. Cloud cover is a qualitative phenomenon characterised by discontinuity in time and space, as well as a local scope. There is no instrument that would accurately measure clouds and visual observation only brings an estimated evaluation of the cloud cover and genera.

Climatologic literature often mentions inaccuracy of cloud cover assessment and lack of homogeneity in the observation data. There were attempts to improve both the nephologic observation and the data processing methods (Warakomski and Wyleżyńska 1965; Owczarek 1993). In the past, the direction and speed of cloud movement were measured with the Besson and mirror nephoscopes and later combined all-sky photographs were used for cloud panem research over small areas (Lenart 1973). Currently, satellite pictures are used more and more providing precision data on high clouds and cloud cover. On the ground, light detection cloud base altitude methods are increasingly employed.

This paper aims to present the most frequent methodical errors made in visual nephologic observations.

The data used come from cloud observations made at the Jagiellonian University climatologic station in Cracow. 'Metadata', or information on the bistory of nephologic observations in Cracow turns out to be hugely important for research as both the place and method of assessment of cloud cover and genera bad not changed here for almost one hundred years. Errors made here are likely to be not just of local but also universal nature.

INTERNATIONAL CLOUD ATLAS AS THE YARDSTICK OF NEPHOLOGIC OBSERVATION

There is an infinite number of cloud forms as they are constantly undergoing transformations. However, classification is possible thanks to a number of typical forms frequently observed in all parts of the world. First attempts at such classifications were made as early as the beginning of the 19th Century.

Lamarck (1802) published the first classification; he defined five main and severa! additional cloud types and applied French terminology. Despite his very thorough approach, Lamarck's method found few supporters. Instead, a far simpler classification by Howard (1803), involving appearance and altitude, quickly spread throughout Europe. It benefited from Latin terminology just as in the case of plant and wildlife names. Hildebrandsson, Koppen and Neumayer (1890) used Howard's classification as the basis for their first cloud atlas (Hamburg Cloud Atlas). The international cloud classification approved for generał use by the Meteorological Congress in Munich was introduced to Poland by Kwietniewski (1891), who, however, commented that „observation of cloud shapes is a very difficult task; rendering them in a drawing or description belongs to the least easy tasks".

In 1894, the International Commission for the Research of Clouds published a report from its meeting in Uppsala on the preparation of an international cloud atlas. The atlas was prepared by Hildebrandsson, Riggenbach and Teisserenc de Bort with 27 illustrations and 24 photographs of clouds with descriptions and published during the International Meteorological Conference in Paris in 1896. The Conference also named the period between May 1896 and May 1897 International Year of Clouds and all major meteorological institutions (including the Cracow Jagiellonian University observatory) were invited to initiate cloud observation series and research.

The second slightly revised and supplemented edition of the International Atlas of Clouds was published in 1910. A new and large atlas was a result of more than a dozen of years of work by the International Commission for the research of clouds followed by an abbreviated Short Atlas (1932) specially for the observers. This International Atlas of Clouds and outlooks of the sky included

175 tables with cloud definitions and explanations for the observers. For the first time, it provided a breakdown of clouds into families, genera, types and varieties (just as in other natural sciences). The following atlas, a short version of which is stili used in Polish weather stations, was published in Geneva in 1956. lt comprised two volumes: one with textual descriptions and the other with black and white and colour photographs illustrating the text. The introduction to the International Atlas of Clouds (1959) states that it is a "basie work covering a detailed descriptive study of clouds and the ways of their observation".

BASIC PROBLEMS IN VISUAL CLOUD COVER ASSESSMENT

Assessment of the cloud coverage, i.e. to what extent the sky is covered by clouds raises virtually no doubts. Naturally, the most credible assessment is that of a elear sky (O) or full cover (8). The most frequent errors made in the cloud cover assessment include:

- Overestimation of clouds close to the horizon;
- Overestimation of the top part of the sky;
- Underestimation of the cloud cover after the sunset caused by bad visibility.

A far more difficult task is posed by the qualitative cloud assessment, i.e. the correct determination of cloud genera, types and varieties. Cloud altitude makes the determination of the appropriate family easy, but the division into types does sometime pose a problem. In the high altitude clouds errors occur in differentiating between Ci and Cs when the *Cirrus* clouds are close to the horizon and the air perspective makes them similar to *Cirrostratus*. The layer Cs can also sometimes be mistaken for an As or St if they are close to the horizon and in the direction of the Sun. Nonnally a halo indicates a Cs. Identification of Ac and As clouds is nonnally correct. If the meteors accompanying a *Nimbostratus* are not taken into account, it can be easily mistaken for a Cb, As, Sc and even an St, because an Ns may resemble these clouds especially when they are thick and the observer is located just below the cloud base. Observers regard a Cumulus as one of the easiest to identify, but, according to Lenart (1976) this is not the case. He quotes cases of Cu clouds identified as Sc when they assumed the form of individual clouds of genus Sc. In this way the proportion of the *Stratocumulus* in total cloud cover was overestimated. There was also a danger of mistaking Cu fra for St fra or Ns pannus. Of course, the distinguishing feature is that St fra and Ns pannus develop below the main condensation altitude. Small *Cumulus* clouds may be so numerous and densely packed that they may resemble a layer of *Stratocumulus* or *Altocumulus*, especially if found near the horizon. According to the International Atlas of Clouds (1959), these clouds ought to be regarded as ***Cumulus*** as long as their peaks remain dome-shaped and their bases are separated. Some Cb clouds look almost identical to large, well-developed Cu. A cloud not accompanied by thunder, lightnings or hail-stonn cannot be unequivocally identified as a Cb.

METHODOLOGICAL DOUBTS IN THE EARLY YEARS OF NEPHOLOGIC OBSERVATION

In the early years of nephologic research, clouds that caused most problems were Ns and Cb, as well as Sc and St.

During that period, the occurrence frequency was probably overestimated for the Ns cloud (Fig. 1) and underestimated for Cb (Fig. 2) as a result of im-

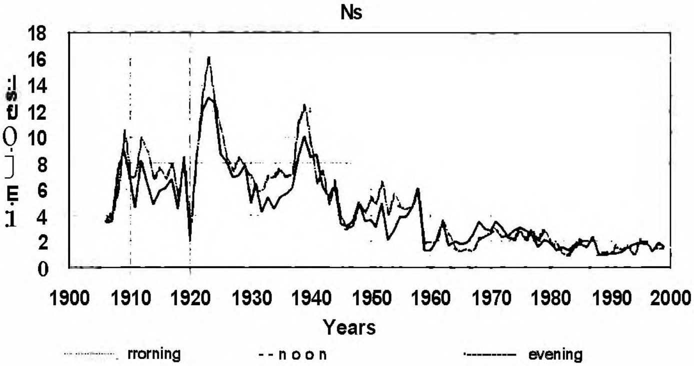

Fig. 1 Multi-annual course of the Ns cloud genus frequency in Cracow (1906-1999)
Wieloletni przebieg częstości występowania chmur Ns w Krakowie (1906-1999)

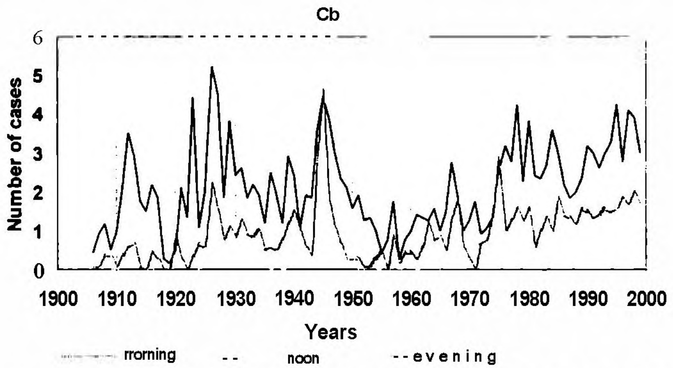

Fig. 2 Multi-annual course of the Cb cloud genus frequency in Cracow (1906-1999)
Wieloletni przebieg częstości występowania chmur Cb w Krakowie (1906-1999)

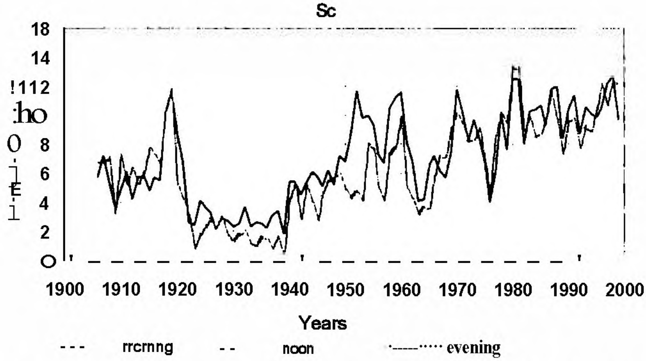

Fig. 3. Multi-annual course of the Sc cloud genus frequency in Cracow (1906-1999)
Wieloletni przebieg częstości występowania chmur Sc w Krakowie (1906-1999)

precise cloud classification applicable until 1932. There were cases of a thunderstonn (Matuszko and Bielec 1998) when Ns clouds were recorded instead of Cb. This could have been caused by the intemational classification in the Atlas that was in use at least until 1932, where a separate *Nimbus* rain cloud was defmed.

Another doubtful observation is the high number of Sc clouds recorded at the beginning of the 20th century (Fig. 3). It seems that the high frequency of this cloud (more than 10) may be a result of inaccurate observation and classification methodology. Sc was probably recorded instead of St, as this cloud is very infrequent exactly during 1906-1920 (Fig. 4). This is further confinned by the fact that only during this period the Sc cloud occurred most frequently in the moming while during other periods they prevailed at midday and in the evening. In Cracow, in the momings and particularly during the early observation period, fog and the St clouds, blocking the view to higher cloud levels,

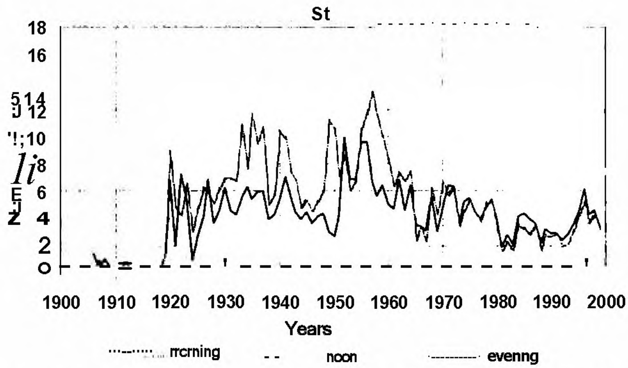

Fig. 4. Multi-annual course of the St cloud genus frequency in Cracow (1906-1999)
Wieloletni przebieg częstości występowania chmur St w Krakowie (1906-1999)

constituted a large proportion of the total cover. At the beginning of the 20^{th} century, major marshlands and cut-off river bends stili existed within the city causing high air humidity. Such conditions were conducvive to the formation and persistence of fog and low layered clouds, particularly in the poorly ventilated and prone to inversion Vistula valley. Regulation of the river, involving reduction of its length within the city limits by four kilometres by cutting the bends and the erection of water thresholds, and drainage of the land caused a drop in the air humidity and possibly contributed to the lower frequency of the St clouds.

SUMMARY AND CONCLUSIONS

The unique one hundred-year long nephologic observation series of Cracow, fully documented, may serve as a basis for a methodological study on the visual could cover assessment.

This paper is an attempt to present doubts arising as to nephologic observations. It certainly does not exhaust the issue, but just indicates the most frequent errors made in assessing the cloud cover. While visual observations are widely regarded as less objective than instrumental measurements, they should not carry less weight so far as scientific research is concemed. lt is different because it deals with qualitative phenomena we stili cannot measure otherwise. An experienced observer with expertise and intuition with regards to atmospheric processes, and who keeps to instructions provided in the atlas of clouds, should be capable to assess the cloud cover very accurately.

However, for correct cloud identification it is necessary to virtually constantly monitor the sky and follow the cloud development. Other helpful information includes the relative cloud altitude and the meteors accompanying the clouds, and in particular the hydrometeors, which could pay a crucial role in cloud identification. Clouds appearing close to the horizon should be treated carefully as they are the prime source of errors in the quantity and quality of the cloud cover.

Currently, the Web constitutes a valuable tool for the correct cloud assessment. Web-based cloud atlases with photographs of clouds of genera, types and varieties of clouds are easy to leam. Additional assistance is provided by airport information services with measured cloud bases.

Despite the methodical difficulties inherent in the visual assessment method, the role of the cloud cover as a comprehensive indicator of the developments in the atmosphere and an important climate-building factor should not be omitted in climatologic research.

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STRESZCZENIE

Mimo że nasz codzienny, świadomy kontakt z atmosferą rozpoczyna się właśnie od spojrzenia na niebo, to badanie zachmurzenia okazuje się zadaniem bardzo trudnym. Zachmurzenie należy bowiem do zjawisk jakościowych, które charakteryzuje nieciągłość czasowa i przestrzenna, a ich zasięg często bywa lokalny. Nie istnieje przyrząd, którym można by precyzyjnie zważyć lub zmierzyć chmury, a obserwacje wizualne tylko w przybliżeniu pozwalają na oszacowanie wielkości pokrycia nieba chmurami i określenie ich rodzajów.

Celem niniejszego opracowania jest próba przedstawienia najczęściej popełnianych błędów metodycznych w ocenie stosunków nefologicznych.

W opracowaniu wykorzystano wyniki obserwacji zachmurzenia pochodzące z krakowskiej stacji klimatologicznej Uniwersytetu Jagiellońskiego. "Metadata", czyli informacje na temat hi-

storii obserwacji nefologicznych w Krakowie posiadają ogromne znaczenie dla badań naukowych. Zarówno miejsce, jak i metodyka szacowania stopnia zachmurzenia oraz określania rodzajów chmur nie ulegały tu istotnym zmianom przez prawie sto lat.

Przykładem chmur, których ocena w początkowych latach badań (do lat trzydziestych XX wieku) budziła najwięcej wątpliwości, były Ns i Cb.

Prawdopodobnie w tym okresie częstość występowania chmury Ns była zawyżona, zaś chmur Cb zaniżona, w wyniku nieprecyzyjnej klasyfikacji chmur obowiązującej do 1932 roku. Wówczas zdarzały się sytuacje, iż występowała burza (Matuszko, Bielec 1998), a nie notowano chmury Cb, lecz Ns. W ***Międzynarodowym atlasie chmur*** z 1910 roku, który obowiązywał przynajmniej do 1932 roku, wyróżniano chmurę deszczową *Nimbus.* Taka klasyfikacja mogła stanowić przyczynę nieporozumień przy odróżnianiu chmur Cb od Ns. Obecnie także mogą zdarzyć się błędy obserwatorów przy określaniu chmur deszczowych, gdyż chmury Cb niejednokrotnie towarzyszą chmurom Ns. Według ***Międzynarodowego atlasu chmur*** (1959) chmury Ns mogą powstawać przez rozpościeranie się chmur Cb, a chmura Cb może tworzyć się w wyniku przekształcenia i rozbudowania jakiejś części chmury Ns.